

1. A welding gun for spot welding a workpiece whereupon a weld nugget is formed that expands and then becomes plastic during the spot welding process, the welding gun comprising:
  - 4 two electrodes, at least one electrode being movable with respect to the other electrode;
  - 6 a power source operative to provide welding power to the electrodes for forming the weld nugget;
  - 8 an electric servo actuator operative to move the at least one movable electrode toward the other electrode such that the electrodes contact opposite sides of the workpiece, the actuator operative to apply a predetermined amount of force to the workpiece;
  - 10
  - 12 a force sensor in communication with at least one of the two electrodes, the force sensor operative to detect an increase in force on the at least one electrode when the weld nugget expands and a decrease in force when the weld nugget becomes plastic, the force sensor further operative to produce a signal indicative of the increase and decrease in force; and
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  - 16
  - 18 a controller in communication with the force sensor and the power source, the controller operative to receive the signal from the force sensor and to cause the power source to stop providing welding power to the electrodes after the force sensor detects the decrease in force due to the weld nugget becoming plastic.
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2. The welding gun of claim 1, wherein the controller immediately causes the power source to stop providing welding power to the electrodes when the force sensor detects the decrease in force.
3. The welding gun of claim 1, wherein the controller is further in communication with the servo actuator and operative to control the servo actuator so as to

control movement of the at least one movable electrode in response to receiving the  
4 signal from the force sensor.

4. The welding gun of claim 3, wherein the controller is further operative to  
2 cause the electrodes to continue contacting the weld nugget when the weld nugget  
becomes plastic.

5. The welding gun of claim 3, wherein the controller is further operative to  
2 cause the actuator to move the at least one movable electrode toward the other electrode  
when the weld nugget becomes plastic.

6. The welding gun of claim 1, wherein the controller is further operative to  
2 cause the electric servo actuator to apply increased force to the workpiece when the force  
sensor indicates an increase in force due to the weld nugget expansion.

7. The welding gun of claim 1, wherein a contact position is defined as the  
2 position of the movable electrode when the electrodes contact the workpiece and the  
predetermined amount of force is applied to the workpiece, the actuator being further  
4 operative to substantially maintain the contact position when the weld nugget expands.

8. The welding gun of claim 1, wherein a contact position is defined as the  
2 position of the movable electrode when the electrodes contact the workpiece and the  
predetermined amount of force is applied to the workpiece, the welding gun further  
4 comprising a position sensor for sensing the position of the at least one movable  
electrode, the position sensor operative to detect a negative change in position when the  
6 at least one movable electrode moves away from the other electrode and a positive  
change in position when the at least one movable electrode moves toward the other  
8 electrode, the position sensor further operative to produce a signal indicative of the  
negative or positive change in position, the controller further being in communication

10 with the position sensor and the actuator, the controller further being operative to substantially maintain the contact position when the weld nugget expands.

9. A welding gun for spot welding a workpiece whereupon a weld nugget is formed that expands and then becomes plastic during the spot welding process, the welding gun comprising:

4 two electrodes, at least one electrode being movable with respect to the other electrode;

6 a power source operative to provide welding power to the electrodes for forming the weld nugget;

8 an electric servo actuator operative to move the at least one movable electrode toward the other electrode such that the electrodes contact opposite sides of the workpiece, the actuator operative to apply a predetermined amount of force to the workpiece, a contact position being defined as the position of the movable electrode when the electrodes contact the workpiece and the predetermined amount of force is applied to the workpiece;

14 a position sensor for sensing the position of the at least one movable electrode, the position sensor operative to detect a negative change in position when the at least one movable electrode moves away from the other electrode and a positive change in position when the at least one movable electrode moves toward the other electrode, the position sensor further operative to produce a signal indicative of the negative or positive change in position; and

20 a controller in communication with the position sensor, the actuator, and the power source, the controller operative to receive the signal from the position sensor and to cause the actuator to apply an increased amount of force to the workpiece when the position sensor detects a negative change in position relative to the contact position, the controller further operable to cause the power source to stop providing welding power to the electrodes when the position sensor detects a positive change in position relative to the contact position.

10. The welding gun of claim 9, wherein the controller immediately causes the  
2 power source to stop providing welding power to the electrodes when the position sensor  
detects the positive change in position relative to the contact position.

11. The welding gun of claim 9, wherein the controller is further operative to  
2 cause the electrodes to continue contacting the weld nugget when the weld nugget  
becomes plastic.

12. The welding gun of claim 9, wherein the controller is further operative to  
2 cause the actuator to move the at least one movable electrode toward the other electrode  
when the weld nugget becomes plastic.

13. A method of spot welding a workpiece whereupon a weld nugget is  
2 formed that expands and then becomes plastic during the spot welding process, the  
method comprising the steps of:

4 providing a welding gun having two electrodes wherein at least one electrode is  
movable with respect to the other electrode;

6 providing a power source in communication with the two electrodes wherein the  
power source is operative to provide welding power to the electrodes for forming the  
8 weld nugget;

10 providing an electric servo actuator that is operative to cause the at least one  
movable electrode to move toward and away from the other electrode;

12 providing a force sensor in communication with at least one of the two electrodes  
for detecting the force on the electrode;

14 providing a controller in communication with the force sensor and the power  
source;

positioning the workpiece between the electrodes;

16 moving the movable electrode towards the other electrode until the electrodes  
contact opposite sides of the workpiece;

18           utilizing the actuator to apply a predetermined amount of force to the workpiece  
with the electrodes such that the electrodes are positioned in a contact position;  
20           providing welding power to the electrodes such that a weld nugget is formed  
between the electrodes and expands and then becomes plastic;  
22           sensing the force on the electrode;  
              maintaining the electrodes substantially in the contact position while the weld  
24           nugget expands; and  
              controlling the power source via the controller to stop providing power to the  
26           electrodes after the force sensor detects a decrease in force due to the weld nugget  
becoming plastic.

14.        The method of claim 13, further comprising the step of moving the at least  
2           one movable electrode towards the other electrode when the force sensor detects the  
decrease in force due to the weld nugget becoming plastic.

15.        The method of claim 13, wherein the maintaining step comprises utilizing  
2           the actuator to increase the force applied to the workpiece by the electrodes while the  
weld nugget expands.

16.        A method of spot welding a workpiece whereupon a weld nugget is  
2           formed that expands and then becomes plastic during the spot welding process, the  
method comprising the steps of:  
4           providing a welding gun having two electrodes wherein at least one electrode is  
movable with respect to the other electrode;  
6           providing a power source in communication with the two electrodes wherein the  
power source is operative to provide welding power to the electrodes for forming the  
8           weld nugget;  
              providing an electric servo actuator that is operative to cause the at least one  
10          movable electrode to move toward and away from the other electrode;

providing a position sensor for sensing the position of the at least one movable electrode;

12 providing a controller in communication with the position sensor and the power source;

14 positioning the workpiece between the electrodes;

16 moving the movable electrode towards the other electrode until the electrodes contact opposite sides of the workpiece;

18 utilizing the actuator to apply a predetermined amount of force to the workpiece with the electrodes such that the electrodes are positioned in a contact position;

20 providing welding power to the electrodes such that a weld nugget is formed between the electrodes and expands and then becomes plastic;

22 sensing the position of the movable electrode;

24 maintaining the electrodes substantially in the contact position while the weld nugget expands and allowing the electrodes to move towards each other when the weld nugget becomes plastic; and

26 controlling the power source via the controller to stop providing power to the electrodes after the position sensor detects the electrodes move towards one another from the contact position when the weld nugget becomes plastic.

17. The method of claim 16, wherein the maintaining step comprises utilizing the actuator to increase the force applied to the workpiece by the electrodes while the weld nugget expands.